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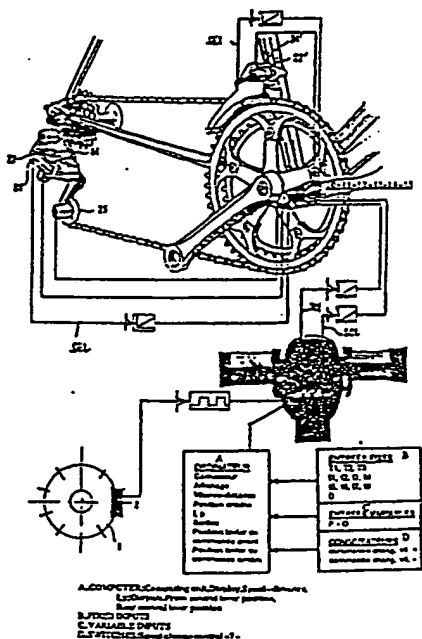
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(54) Title: RATIO SELECTION DEVICE FOR MUSCLE-POWERED VEHICLES, PARTICULARLY BICYCLES



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The present invention concerns a ratio selection device for muscle-powered vehicles, especially for a bicycle.

The optimal operational output of the crankset of a muscle-powered vehicle is obtained for a certain number of revolutions  $P$  of the pedals per minute, generally between 70 and 120 rpm. In the case of a bicycle, this rate  $P$  is different for each cyclist, but should, preferably, remain constant under all circumstances.

In order to enable a cyclist to maintain his optimal rate, current bicycles (town bicycles, all-terrain bicycles, racing bicycles) are equipped with a rear changer and often a front changer that can offer up to 24 ratios by their combination.

The well known problem for each cyclist is to permanently choose the proper ratio so that the rate of the crankset enables him to best exploit the power that he is capable of delivering at each moment.

Thus, assuming that the power developed by the cyclist is constant and that the rate of the crankset is kept at the optimal constant, the speed  $V$  (in km/h) of the bicycle varies according to circumstances, especially slope, wind direction, condition of the road, etc.

In fact, the cyclist is fully left to his own devices and sensations to select the ratio and think about doing so. It therefore often happens that a cyclist, failing to have engaged the ratio corresponding to his optimal rate, expends considerable energy and determination for an output lower than he could ideally obtain for the same effort.

To free the cyclist of constant concern about finding the proper ratio, automatic changers have been proposed. These changers, however, are based on fully electronic operation acting on a linear chain guide system, especially an endless screw guide, which replaces the conventional parallelogram guide system. These devices often use low electrical voltages that make them easily perturbable, for example, near high-voltage power lines. They are not very reliable for

this reason. On the other hand, these changers pose wear problems due to linear guiding of the chain.

The purpose of the present invention is to propose a ratio selection device for muscle-powered vehicles, especially for a bicycle, that eliminates the drawbacks of the known devices, and especially maintains an optimal rate of rotation of the crankset of the bicycle.

For this purpose, the invention concerns a ratio selection device for muscle-powered vehicles, especially for a bicycle, comprising at least one crankset, provided with at least one disk and at least one changer, as well as means of control for selection of the ratios, as defined in Claim 1. The invention also concerns the changer as part of the device defined in Claim 9.

According to a preferred variant, the device includes a front disk changer and a rear gear changer, the two changers being of the parallelogram type. These changers are electromechanically operated, in terms of translation of the chain. They are electronically assisted, in terms of selection of the optimal ratio as a function of the relevant parameters.

The device according to the invention permits automatic read-out of data that permit optimization of the operations necessary to maintain a rotation rate of the crankset as constant as possible, so as to optimize and facilitate the effort of the cyclist.

The following description, given as an example, refers to the drawing, in which:

Figure 1 is an elevation of a bicycle provided with an example of the device according to the invention,

Figure 2 illustrates a detail of a coded disk mounted on the front wheel,

Figure 3 is a synoptic chart illustrating a method of operation of the device according to the invention,

Figure 4 is a side view of an example of the front changer group according to the invention,

Figures 5 and 6 are rear views of the changer group of Figure 4, illustrating the mobility of the elements of the changer group,

Figure 7 is a cross section of a detail of the angular localization system,

Figure 8 is a rear view of a second example of the front changer group,

Figure 9 is a rear view of a first example of the rear changer group,

Figure 10 is a side view, partially in cross section, illustrating the mechanism of the rear changer group,

Figure 11 is a rear view of the second example of the rear changer group,

Figure 12 is a side view of the changer group of Figure 11,

Figure 13 is an example of a truth table of operation of the device according to the invention,

Figures 14 and 15 are electrical schematics illustrating one variant of operation of the device according to the invention, and

Figure 16 is an example of an electrical schematic of a comparator and amplifier of the motors of the front and rear changers.

Although the following description refers, in particular, to a ratio selection device of bicycle changers, the characteristics being described can also refer to changers of any other mechanism without major modifications.

The bicycle depicted in Figure 1 contains a front disk changer 5 and a rear gear changer 6, both electronically operated, each of the changers being provided with an electronic device to read a digital or analog electrical signal, indicating the position of the changer. It also comprises a set of standard rear gears 7, as well as a set of front disks 8. Production of electrical power can be ensured by means of a mini-generator 9 mounted on the lower wheel of the chain takeup of the rear changer, so as to supply a static electrical energy storage unit of the unit, and to confirm that the crankset is in rotation. Said unit can be arranged within an electronic housing 10 mounted, for example, in the vertical tube of the bicycle. A general display panel 16 can be arranged on the handlebars.

As shown in Figure 3, the automatic control system 11 of the front changer and the control system 12 of the rear changer are equipped with position sensors that produce digital or analog information, identifying the concerned gear or disk. These data are transmitted to an electronic card, provided with a processor capable of ensuring data processing. This electronic card, which can also be mounted within a housing 10, is capable of managing the system for regulating the feed voltage of the motor and carrying out connection-disconnection of the generator-battery assembly.

A coding disk 1 (Figure 2) is mounted on the axle of the front wheel, rotating in unison with it. Disk 1 contains, for example, a coding distributed around its periphery. A sensor 2 is mounted on the front fork, in order to read the coded point data of the disk, and to transmit the data to an electronic processing circuit 3. Mounting of the coded disk on the axle of the rear wheel, in cooperation with a sensor positioned on the rear fork, can also be contemplated.

The parameters processed by the electronic card can be the following, for example:

fixed input parameters to be programmed at the time of installation of the gears and disks:

- diameter of the wheels
- number of teeth T1, T2 and T3 of the crankset disks
- number of teeth t1 to t8 of the rear gears

programmable parameters:

- ideal rotation rate  $P$  of the crankset in rpm
- dead zone  $O$  (overlap)
- type of program to be chosen by the cyclist (ride, training, race)

parameters analyzed by the electronic card to manage optimal rate:

- instantaneous speed  $V$  of the bicycle in km/h
- disk  $T$  engaged in the front
- gear  $t$  engaged in the rear
- rotation rate  $p$  of the crankset in rpm
- indication of inclination of the transmission chain
- indication of slope of the road
- engaged or disengaged position of the automatic device

possible additional parameters:

- temperature
- applied torque
- heart rate of the cyclist

calculated parameters:

- average cruising speed in km/h
- adder of total distance of the introduced program, covered in km
- counter of the daily distance in km
- total duration of trip in hours, minutes and seconds
- daily duration of travel in hours, minutes and seconds
- proportions of route in flat, rising, descending configuration, according to the data of the inclination sensor.

Two levers 4 and 4' can be arranged on the handlebars near the handles. These levers are designed so that their operation deactivates the automatic device and permits manual selection of



the ratio, useful, for example, during races, to adapt the rate of the crankset in the event of starting, or during climbing under extreme circumstances.

Operation of the automatic changer will now be described.

An increased number of coded points of disk 1, for example, 10, can be chosen. In this case, the sensor unit 2 issues a signal at every tenth revolution of the wheel. Thus, even at very low speed, for example, on a steep hill, the number of pulses is sufficient to reliably account for the speed.

The processor is designed to calculate the speed  $V$  of the bicycle in km/h, the ratio  $i$  and rate of the crankset  $p$  in rpm according to the following formulas:

$$V = (I \times D \times \pi \times 3.6) / n$$

where  $I$  = number of pulses per second,

$D$  = diameter of the wheel in meters

and  $n$  = number of pulses per revolution of the wheel

$$i = T/t$$

where  $T$  is the number of teeth of the engaged front disk

and  $t$  is the number of teeth of the engaged rear gear

$$p = (I \times 6) / i / n$$

The ideal rate  $P$  of the crankset having been stored in the computer, when the instantaneous speed  $p$  of the crankset is less than or greater than the ideal programmed speed  $P$ , the multiplication ratio (gear ratio)  $i$  changes automatically when the computer determines that a similar ratio would give a crankset speed closer to the ideal rotation speed  $P$  than the actual ratio.

An overlap must be programmed, so as to create a dead zone, to avoid changes in ratio for unduly small differences in rotation speed of the crankset.

When a change in ratio must be performed, the processor (Figure 3) issues a signal (SC1 or SC2) to the comparator of the front changer or rear changer, which, in turn, controls the amplifier 11 or 12 of the front motor 22 or rear motor 52. The amplifier 11 or 12 of the motor transmits the power of the battery to the motor. A digital or analog feedback position sensor 19, 19' then emits a signal (SE1 or SE2) to inform the comparator of the position of the front changer or of the rear changer.

When the calculated programmed signal and the feedback signal are equal, the comparator signal is zero and the amplifier stops the motor.

The electronic card is programmed to avoid chain positions, like T1 – t7 or t8, and T3 – t2 or t1, so as to avoid losses of energy or wear of the chain. It will also be assisted in this function by an electronic mechanical chain controller.

As shown in Figures 4 to 12, the front and rear changers can be changers of the standard parallelogram type, in which control of the parallelogram, conventionally with a cable (Bowden cable connected to the handlebars or a tube of the frame), is advantageously replaced by a servo device, comprising an electric motor arranged at the level of the changer, and operating a reducing gear, the output of the reducing gear containing an eccentric that controls the parallelogram by means of a connecting rod arranged in the plane formed by the parallelogram.

The motorized control device of the parallelogram is particularly advantageous relative to control devices proposed thus far, because it eliminates the Bowden cable. Moreover, since the spring ordinarily provided on the devices that have been proposed thus far is no longer necessary, the force necessary for shifting is very low and a motor of low power can execute the lateral translation movement of the chain.

An example of the front changer group is shown in Figures 4 to 6. The motor-reducing gear assembly 22 is mounted on a support element 21 fixed on the frame (not shown) of the bicycle, for example, by means of a screw 20. The motor-reducing gear assembly drives a crankshaft 24 acting on a driving rod that controls translation of guide element 31 of the chain by means of a bent arm 26 and an intermediate rod 29, arm 26 and rod 29 being the elements forming the parallelogram. For this purpose, arm 26 is mounted to rotate around a fixed axis 27, part of the motor support 21, one of its ends being mounted to articulate on the end 28 of driving rod 25, the other end being mounted to articulate 33 on the guide element 31. The intermediate rod 29 is mounted on one of its ends to articulate around a fixed axis 30 that is part of the motor support 21, and on its other end is articulated 32 on the guide element 31.

The electromechanical application principle described above is amenable to various modifications.

According to another variant of the front changer group, as shown in Figure 8, motor 22' operates a reducing gear acting on an eccentric 24', which controls a driving rod 25' arranged on the outside of the parallelogram 26', 29', and which acts at the level of one of the lower axes of rotation of the parallelogram. Chain 36 and the chain guide, saddle tube 37 and front disk 38 are also shown in Figure 8.

An angular localization device is shown in detail in Figure 7, which also shows the support 21 of the motor-reducing gear assembly 22, as well as the crankshaft 24 and driving rod 25. This device comprises a reed sensor element 43 (known per se) controlled by the passage of a magnetic activator element 42 mounted on the end of the axis 40 of the motor-reducing gear assembly.

One will note that indication of the position of the driveshaft can also be obtained by interpreting an analog signal emitted by a potentiometer with a track, integral with the driveshaft.

An example of the rear changer group is shown in Figures 9 and 10. It contains, on the one hand, an upper element 50 attached to the rear element of the frame, for example, by means

of a screw, this element 50 forming the only fixed part of the changer, and, on the other hand, a lower element 61 (of a type known per se). Displacement of the lower element is ensured by deformation of a parallelogram, consisting of two rods 56 and 57 activated by a driving rod 55, itself operated by a motor-reducing gear assembly 52 by means of crankshaft 54. The driving rod 55 is mounted to articulate on one of its ends around an axis 58 that is part of the upper element 50 and on its other end around an axis 65 that is part of crankshaft 54. Axis 58, which represents one of the two fixed points of the parallelogram, is also the axis of articulation of rod 57.

The rear changer group can contain an angular localization device identical to that shown in Figure 7.

A second example of the rear changer group is shown in Figures 11 and 12. This group comprises a motor 82, which operates a reducing gear 83 acting on an eccentric 84, which controls parallelogram 86, 87 by means of a diagonal rod 85, if necessary, controllable. A position sensor 89 is also visible in Figure 11.

The electrical schematics that illustrate one mode of action of a device according to the invention, shown in Figure 14 and 15, refer, in particular, to a device comprising a front changer group, as described in relation to Figure 8, and a rear changer group, as described in relation to Figures 11 and 12.

Figure 16 shows an example of an electrical schematic of the comparator and amplifier of the motors of the front and rear changers.

The device according to the invention permits automatic control with maximum efficiency of the energy of the cyclist without a need for the cyclist to intervene at the level of a ratio change, in all possible configurations. Made according to the preferred variant that has been described, the device according to the invention has the major advantage of being based on a position transfer system because of mobility of a parallelogram, which is a proven system, probably the best known. A purely mechanical system assisted electromechanically is the result.

Electronic processing is not performed at the level of the changer, but at a higher level, which permits very distinct separation of all the electronics from the mechanical parts.

Moreover, as described, it is sufficient for the cyclist to manually carry out a speed change as soon as the command previously given by the computer is cancelled and the manual command is immediately executed. Naturally, in this case, the cyclist must then reactivate the automatic command to again benefit from the integral electronic assistance.

According to one variant, optional external parameters for kick up (KU) and kick down (KD) can be introduced, for example, by means of an external push button control, positioned near one of the handlebar grips. In this case, said control includes a button to control passage of the changer to the next higher position (kick up) and a button for passage of the changer to the previous lower position (kick down) to change the value of the ideal rotation rate  $P$  of the crankset, in order to adapt it to exceptional circumstances (races, climbing under extreme circumstances) without deactivating the automatic electronic assistance.

Among other advantages, the device according to the invention enables an athlete to choose an ideal rate of the crankset with low stress (rapid rate) at the beginning of the season, and to progressively modify these stresses as a function of evolution of his physical condition, or to determine a particular form of training at any time. Moreover, choice of a precise stress program is possible, which permits training to be guided with precision.

## Claims

1. Ratio selection device for muscle-powered vehicles, especially for a bicycle, comprising a crankset provided with at least one disk and at least one changer, as well as means of control for selection of ratios, characterized by the fact that it comprises a computer (13) programmed to calculate the speed  $V$  of the bicycle, the gear ratio  $i$  and the rate of the crankset  $p$  according to the following formula:

$$V = (I \times D \times \pi \times 3.6) / n$$

where  $I$  = number of pulses per second,

$D$  = diameter of the wheel in meters, and

$n$  = number of pulses per revolution of the wheel

$$i = T/t$$

where  $T$  is the number of teeth of the concerned disk

and  $t$  is the number of teeth of the concerned rear gear

$$P = (I \times 60) / i / n$$

and by the fact that comprises means for read-out of data and means of calculation, these means being designed to maintain an optimal rate of rotation of the crankset of the mechanism, and especially to optimize the operations necessary to maintain a constant and previously programmed rate of rotation of the crankset.

2. Device according to Claim 1, characterized by the fact that the computer is programmed to store the ideal speed  $P$  of the crankset, compare the instantaneous speed of the crankset to the ideal programmed speed  $P$  and, when said instantaneous speed is lower or greater than programmed ideal speed  $P$ , to automatically control the change in ratio (gear ratio)  $i$  when it

determines that a nearby ratio would give a speed of the crankset closer to the ideal rotation speed P than the actual ratio.

3. Device according to one of the preceding claims, characterized by the fact that it comprises a front changer (5) and/or a rear changer (6) of the parallelogram type, and by the fact that at least one of the front and rear changers has a device to control movement of parallelogram (26, 29; 56, 57), containing an electric motor (22; 52) arranged at the level of the changer and operating a reducing gear, the output of the reducing gear containing an eccentric (24; 54) that controls movement of the parallelogram by means of a driving rod (25; 55).

4. Device according to Claim 4 [sic], characterized by the fact that the device for controlling movement of the parallelogram of the rear changer has a controllable (55) or uncontrollable (85) diagonal driving rod.

5. Device according to one of the Claims 3 or 4, characterized by the fact that the device for controlling movement of the parallelogram of the front changer contains a diagonal driving rod (25, 25') arranged on the outside of the parallelogram and acting at the level of one of the lower rotation axes of said parallelogram.

6. Device according to one of the preceding claims, characterized by the fact that it contains comparators (14, 15) of the effective position and calculated ideal position signals of the front changer and/or rear changer arranged in a housing (10), also containing an electronic card and amplifiers (11, 12) of the front and rear motors of the changers.

7. Device according to Claim 6, characterized by the fact that the housing (10) also contains an electrical power source.

8. Device according to one of the preceding claims, characterized by the fact that a mini-generator (9) is mounted on the lower guide wheel of the rear changer, so as to supply the energy source, operated by the regulation system.

9. Changer as part of the device according to one of the Claims 1 to 8, characterized by the fact that it contains a front changer (5) and/or a rear changer (6) of the parallelogram type, and by the fact that at least one of the front and rear changers has a control device of movement of the parallelogram (26, 29; 56, 57), containing an electric motor (22; 52) arranged at the level of the changer and operating a reducing gear, the output of the reducing gear containing an eccentric (24; 54) that controls movement of the parallelogram by means of a diagonal driving rod (25; 55).



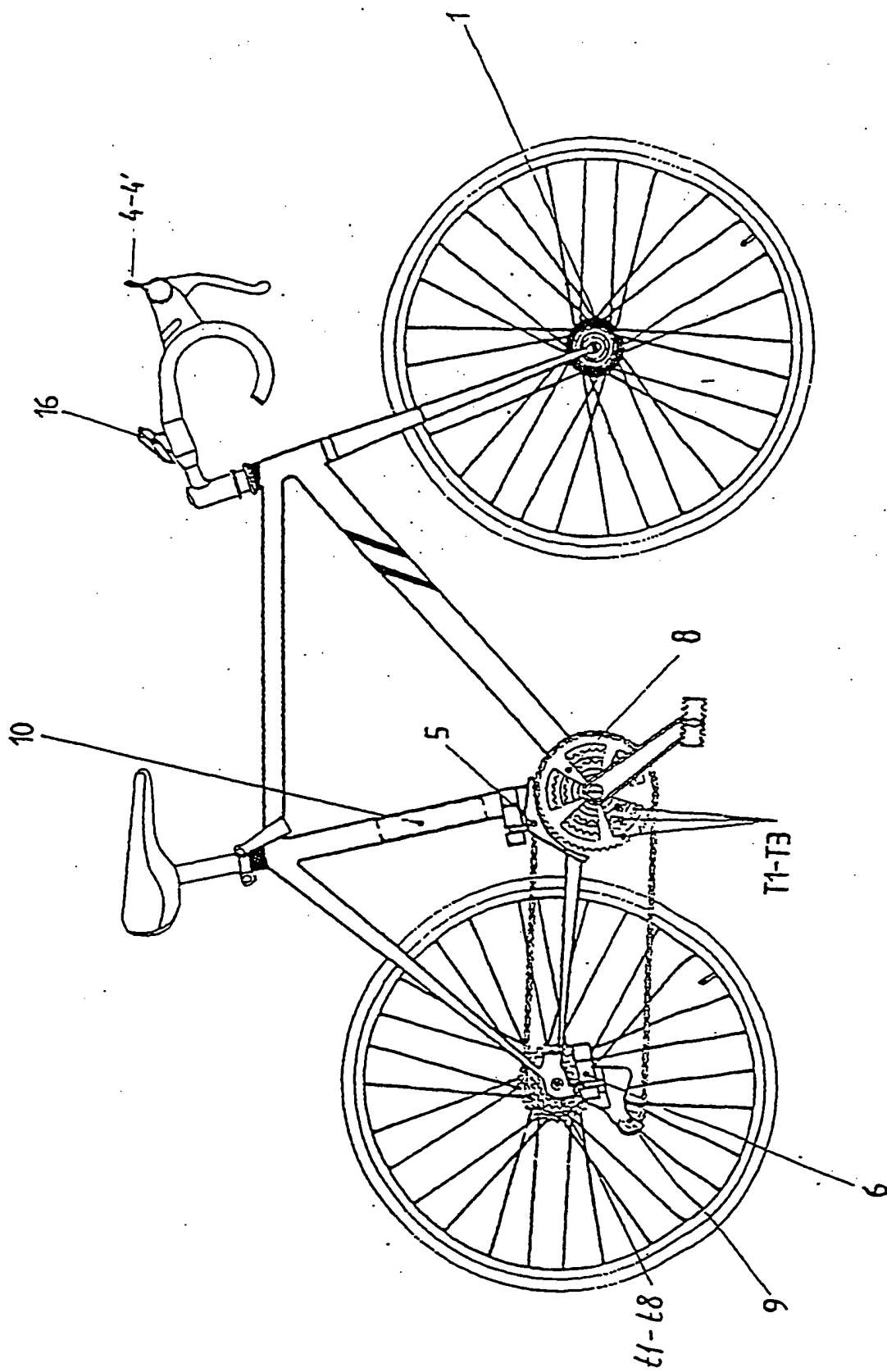
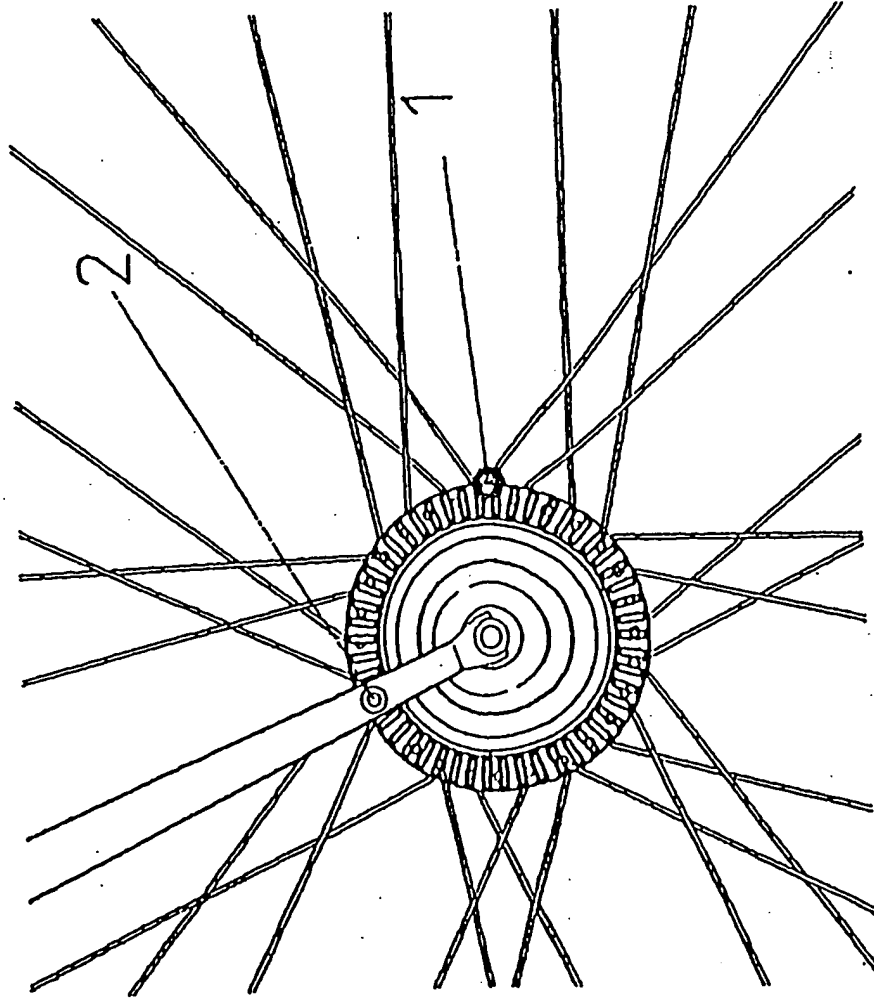


FIG. 1

FIG.2



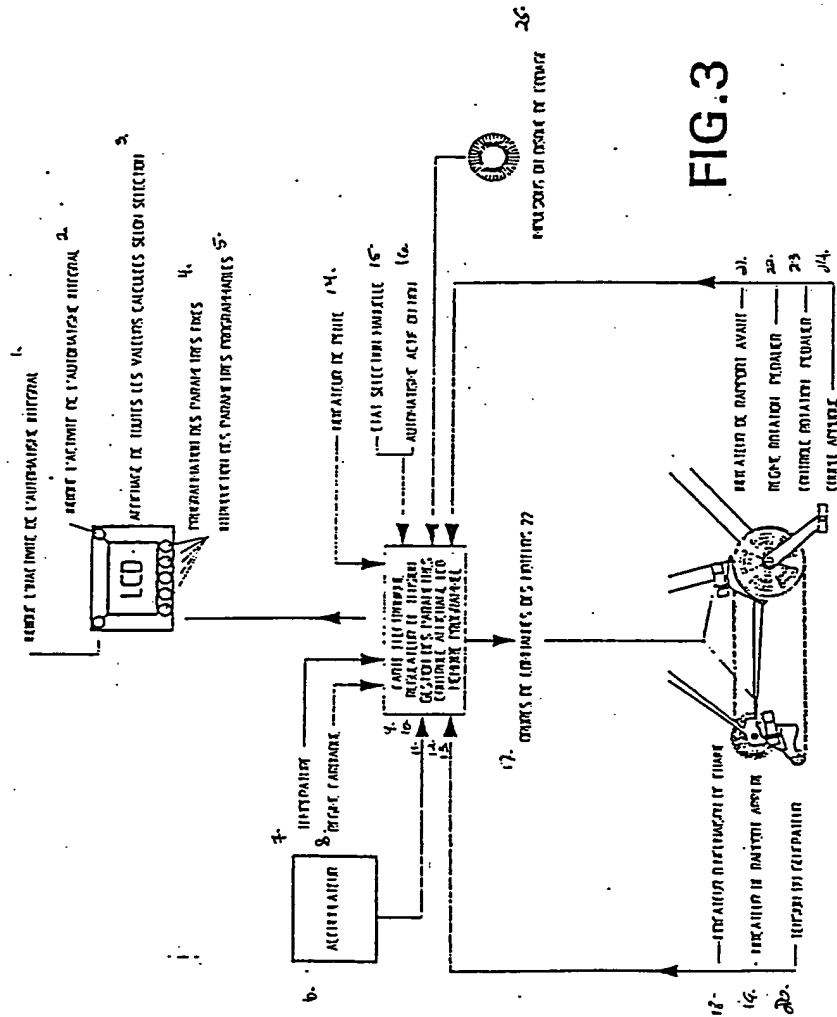


FIG.3

Keys: 1. INDICATES INACTIVITY OF THE INTEGRAL AUTOMATIC DEVICE; 2. INDICATES ACTIVITY OF THE INTEGRAL AUTOMATIC DEVICE; 3. DISPLAY OF ALL VALUES CALCULATED ACCORDING TO SELECTION; 4. PROGRAMMING OF FIXED PARAMETERS; 5. INTRODUCTION OF PROGRAMMABLE PARAMETER; 6. BATTERY; 7. TEMPERATURE; 8. HEART CONDITION; 9. ELECTRONIC CARD; 10. VOLTAGE REGULATOR; 11. MANAGEMENT OF PARAMETERS; 12. LCD DISPLAY CONTROL; 13. PROGRAMMED MEMORY; 14. SLOPE INDICATOR; 15. MANUAL SELECTION MODE; 16. AUTOMATIC DEVICE ACTIVE OR NOT; 17. ORDERS OF COMMANDS OF MOTORS 22; 18. INDICATOR OF CHAIN INCLINATION; 19. INDICATOR OF REAR RATIO; 20. GENERATOR VOLTAGE; 21. INDICATOR OF FRONT RATIO; 22. CRANKSET ROTATION MODE; 23. CRANKSET ROTATION CONTROL; 24. APPLIED TORQUE; 25. PULSES OF THE CODING DISK.

FIG.4

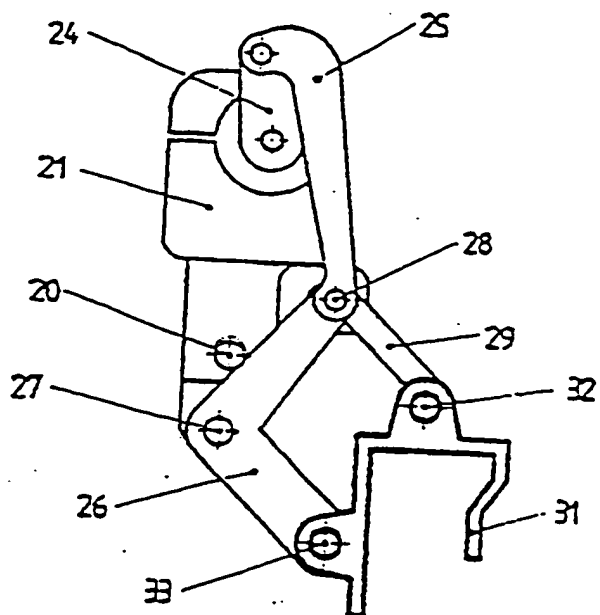
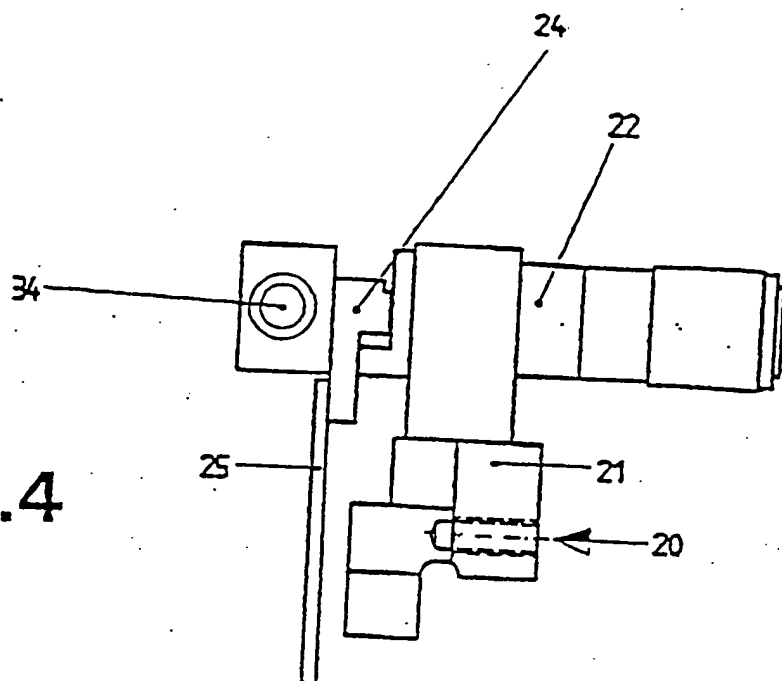


FIG.5

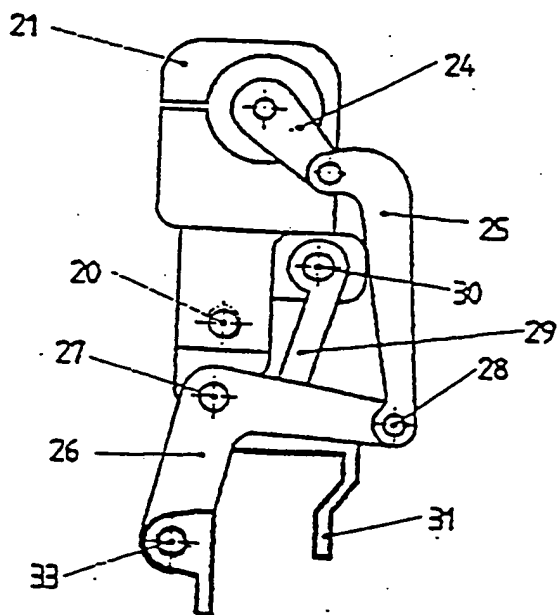


FIG.6

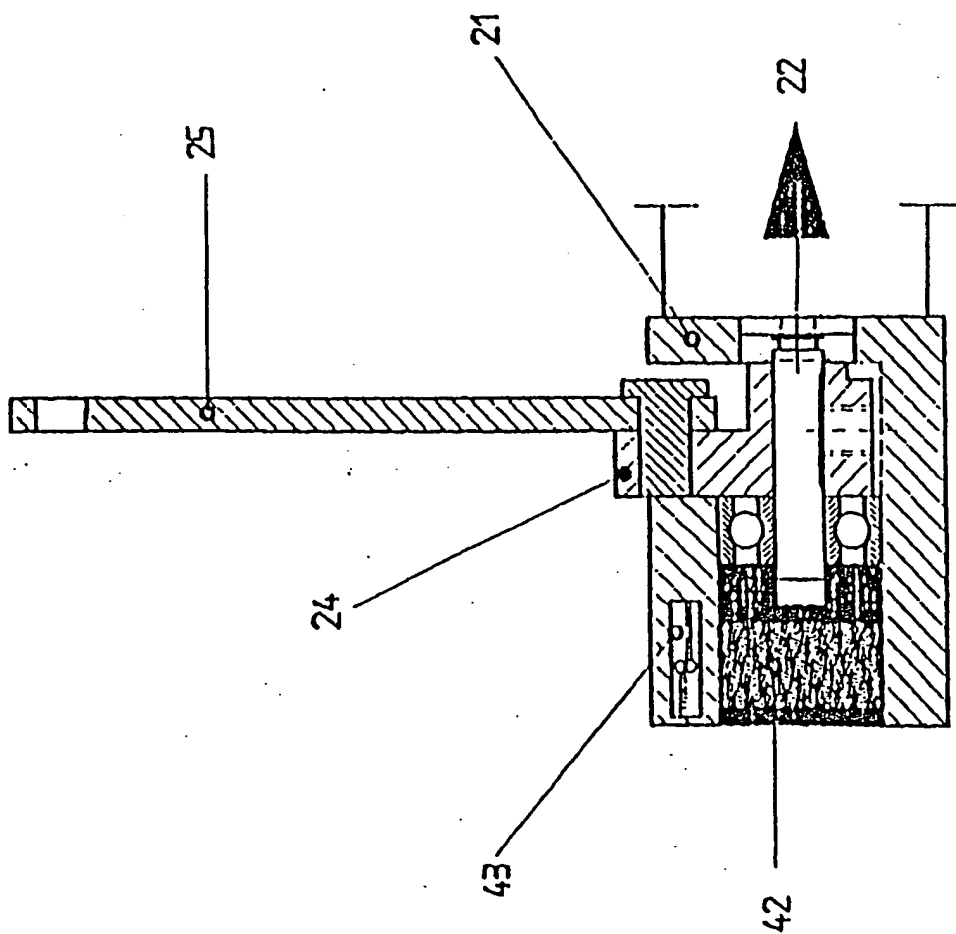
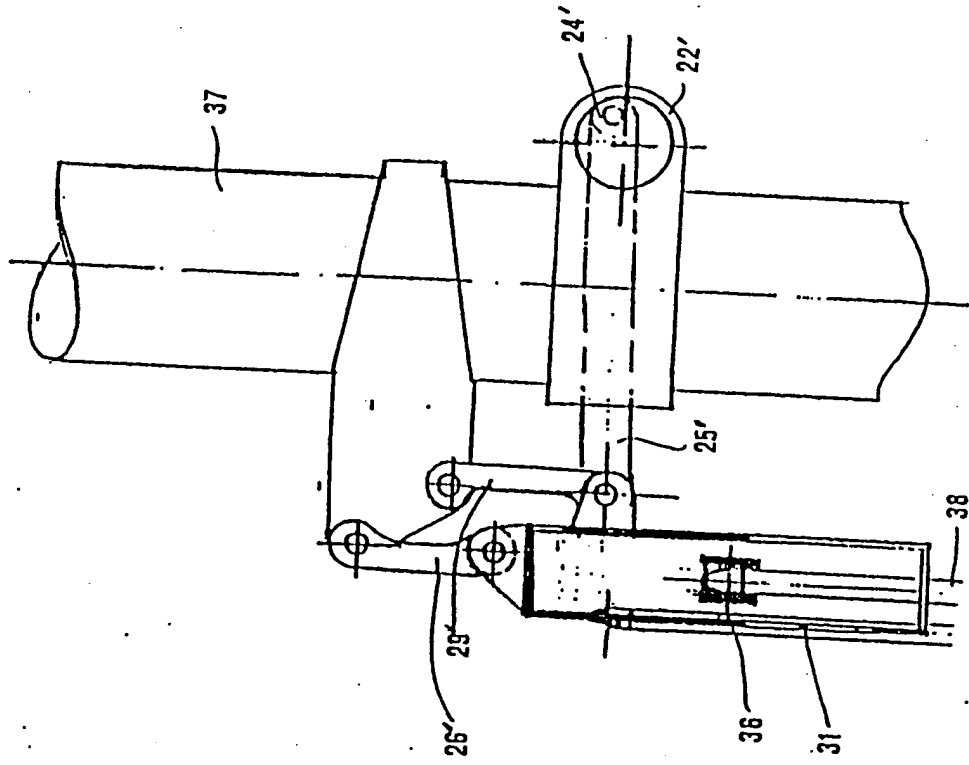
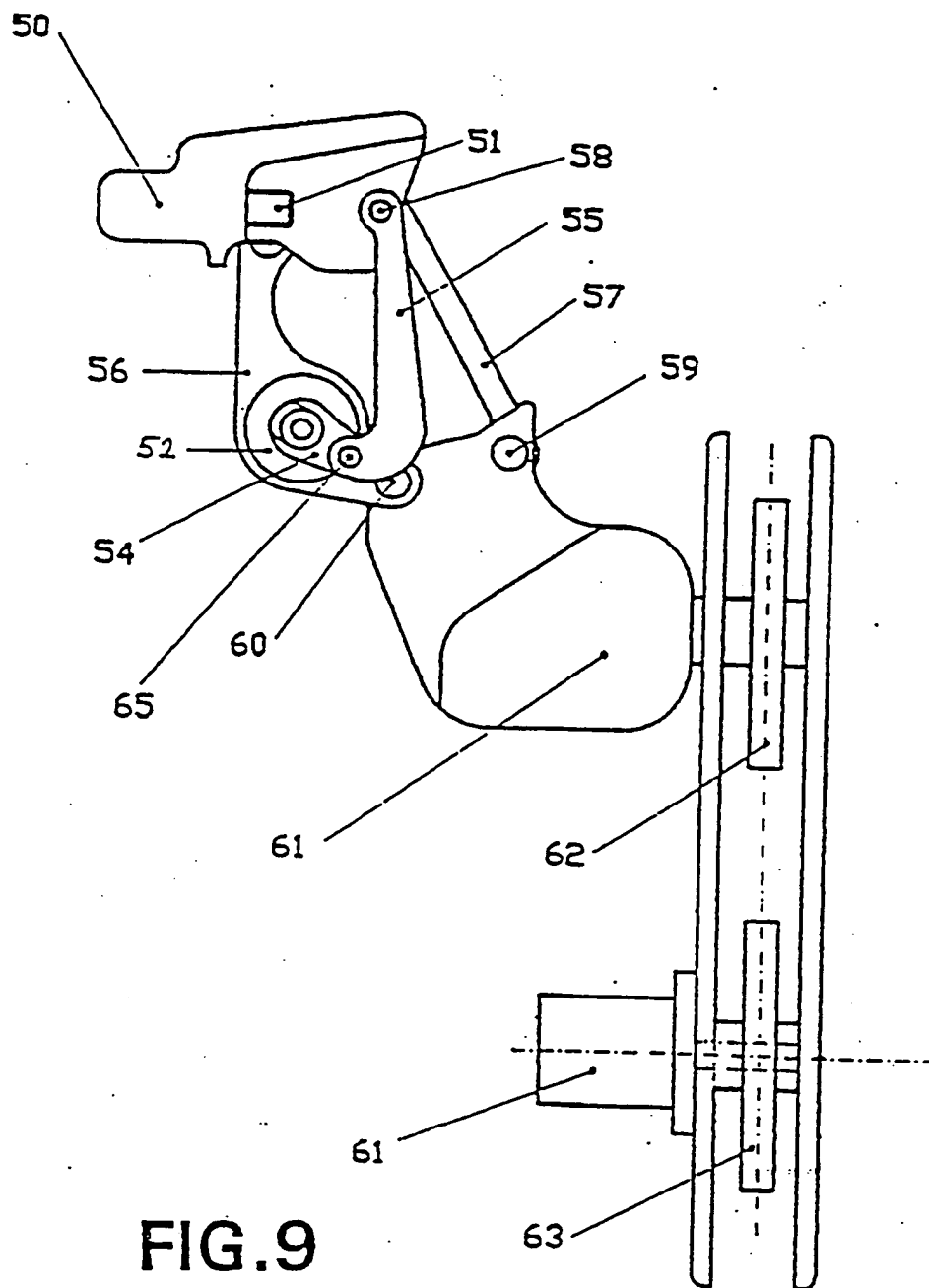


FIG.7

FIG. 8





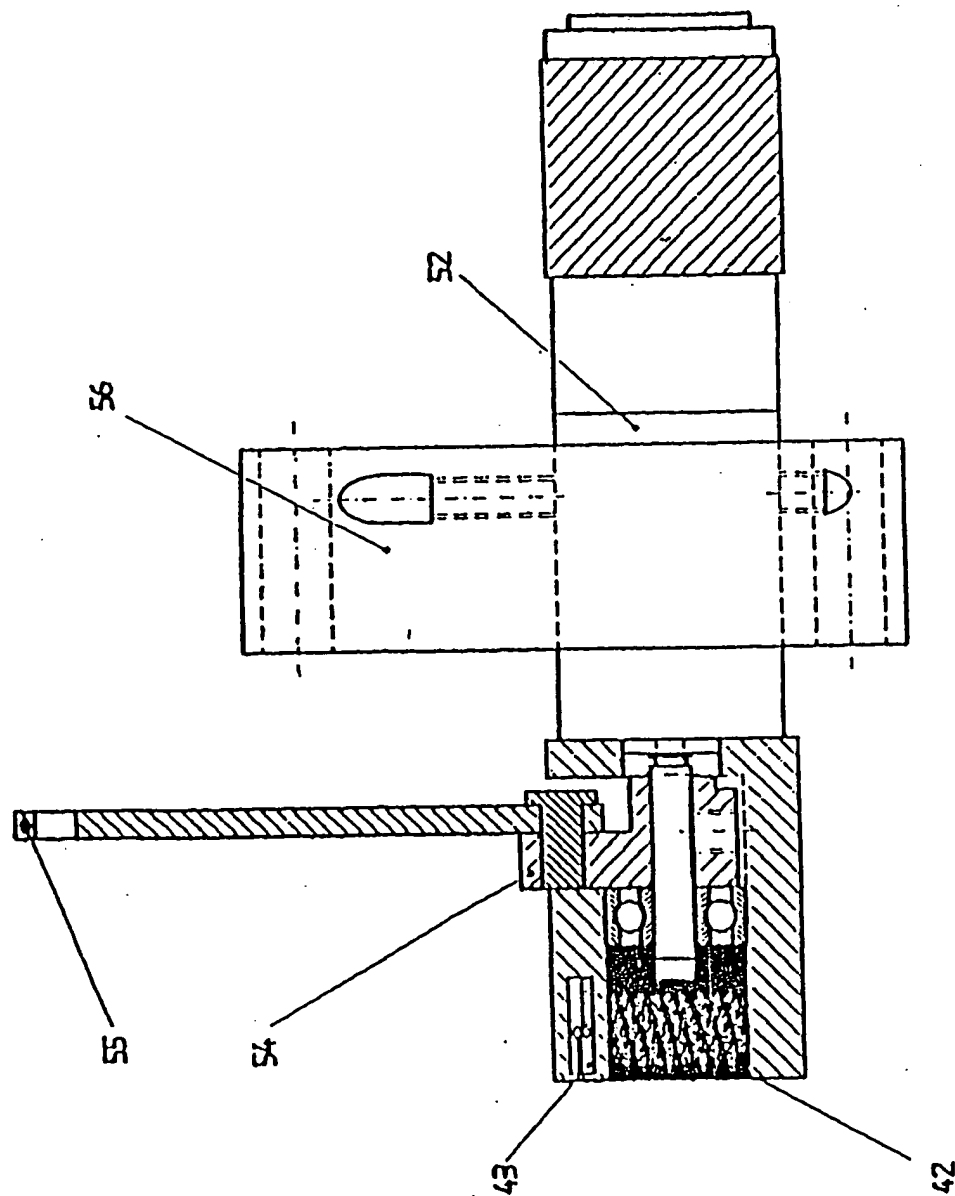


FIG. 10



FIG.11

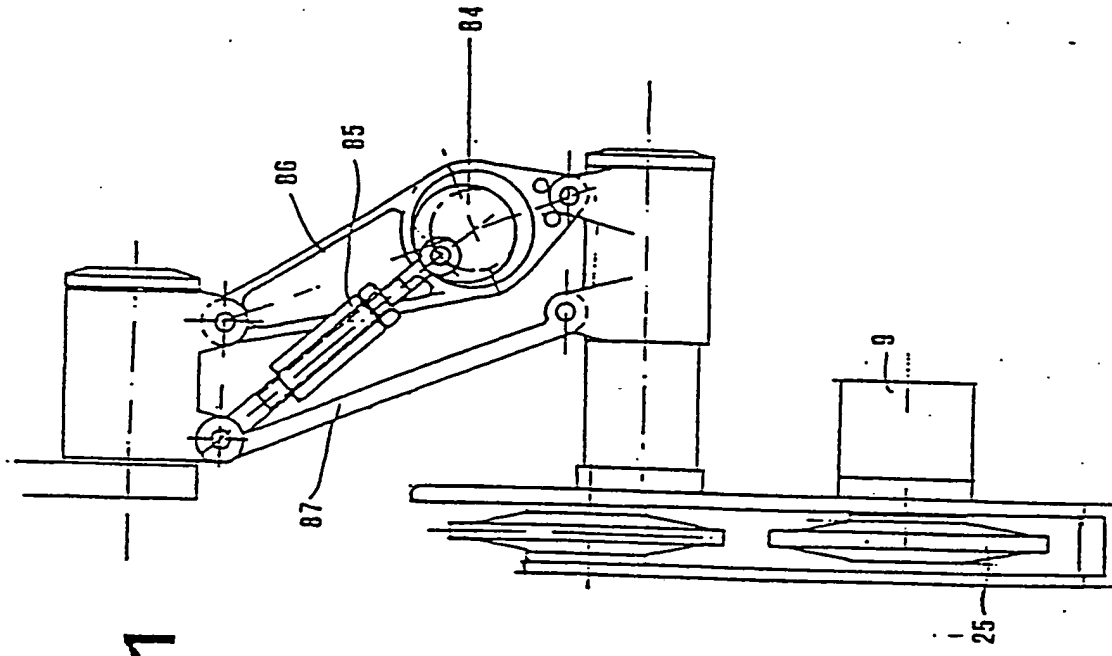


FIG.12

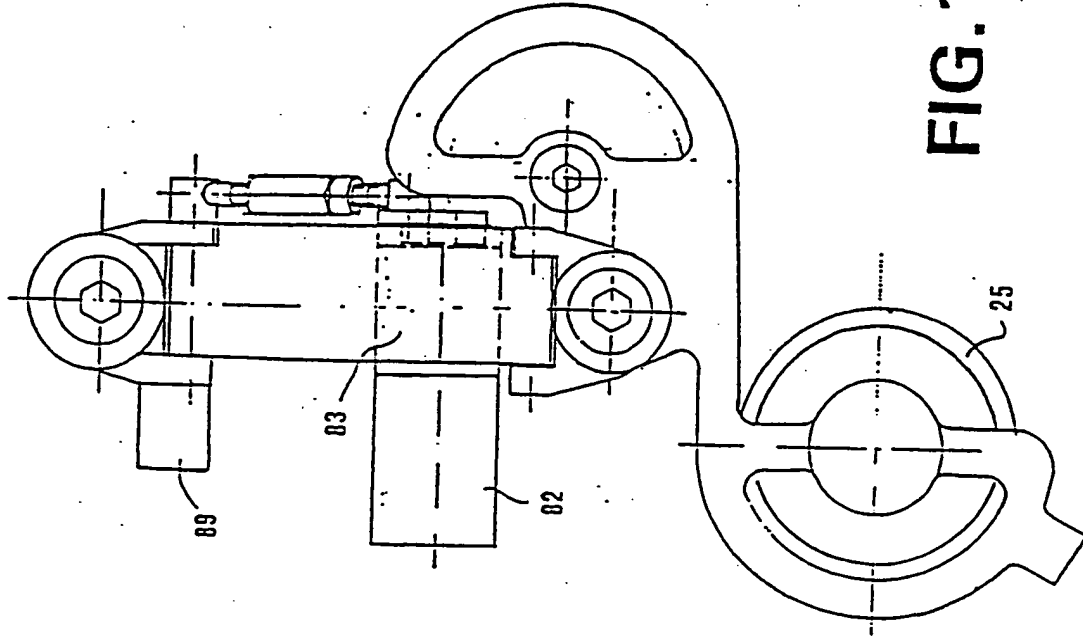


FIG. 13

TRUTH TABLE OF AUTOMATED FUNCTIONS

CONTROL	ROTATION CRANKSET	ROTATION MODE CRANKSET	TRANSLATION SPEED	ROTATION CHANGE	RISE DESCEND
YES/NO	YES/NO	+ / - / -----	+ / - / -----	YES/NO	R/D
YES	YES	-----	-----	YES	ACCORDING TO ORDER
YES	NO	-----	-----	-----	-----
NO	YES	-----	-----	NO	-----
NO	YES	-	-	YES	DESCEND
NO	YES	+	+	YES	RISES
NO	NO	-----	+	NO	-----
NO	YES	-----	+	YES	RISES
SIGNS	+ = increases	- = diminishes	----- = stable		

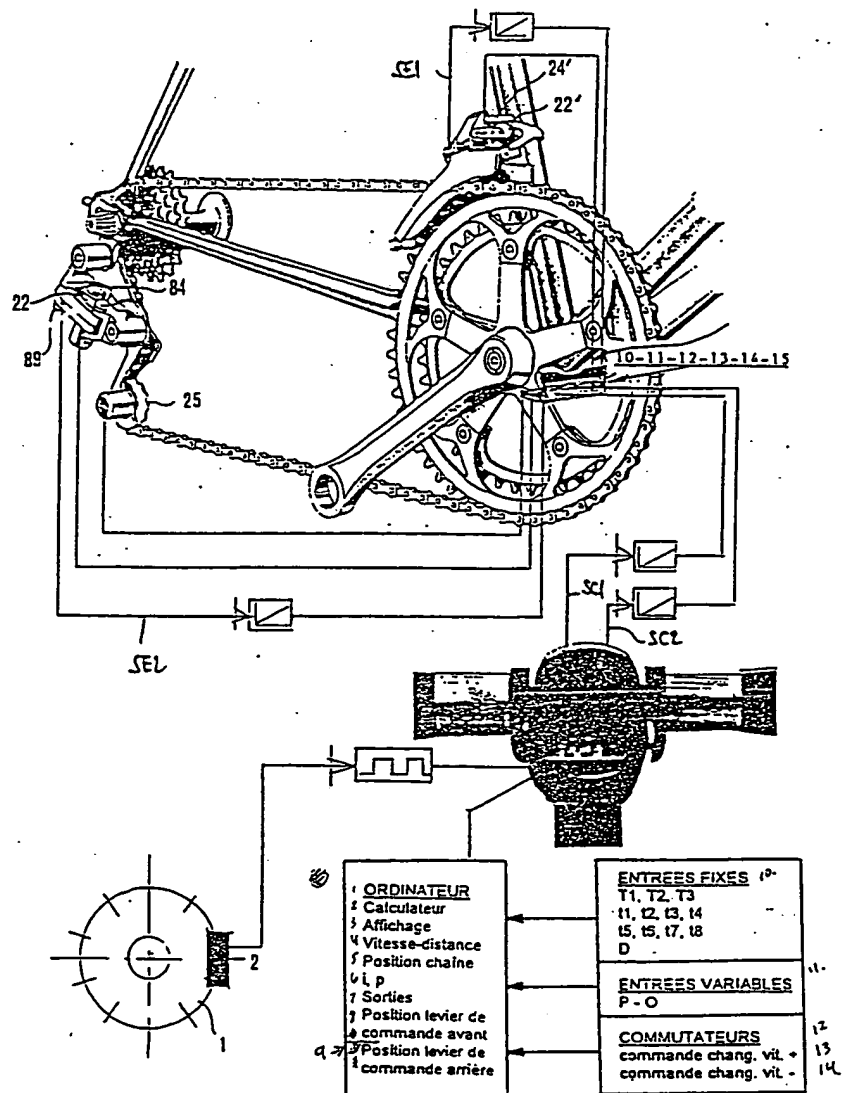
CONTROL: Pulses of control levers on the handlebars.

CRANKSET ROTATION: Control of rotational movement of crankset (direction of traction).

ROTATION MODE: Control of rotation mode of the crankset.

TRANSLATION SPEED: Control of the translation speed of the cycle.

FIG. 14



Keys: 1. COMPUTER; 2. Calculator; 3. Display; 4. Speed-distance; 5. Chain position; 6. i, p; 7. Outputs; 8. Position of front control lever; 9. Position of rear control lever; 10. FIXED INPUTS; 11. VARIABLE INPUTS; 12. COMMUTATORS; 13. speed change control +; 14. speed change control -

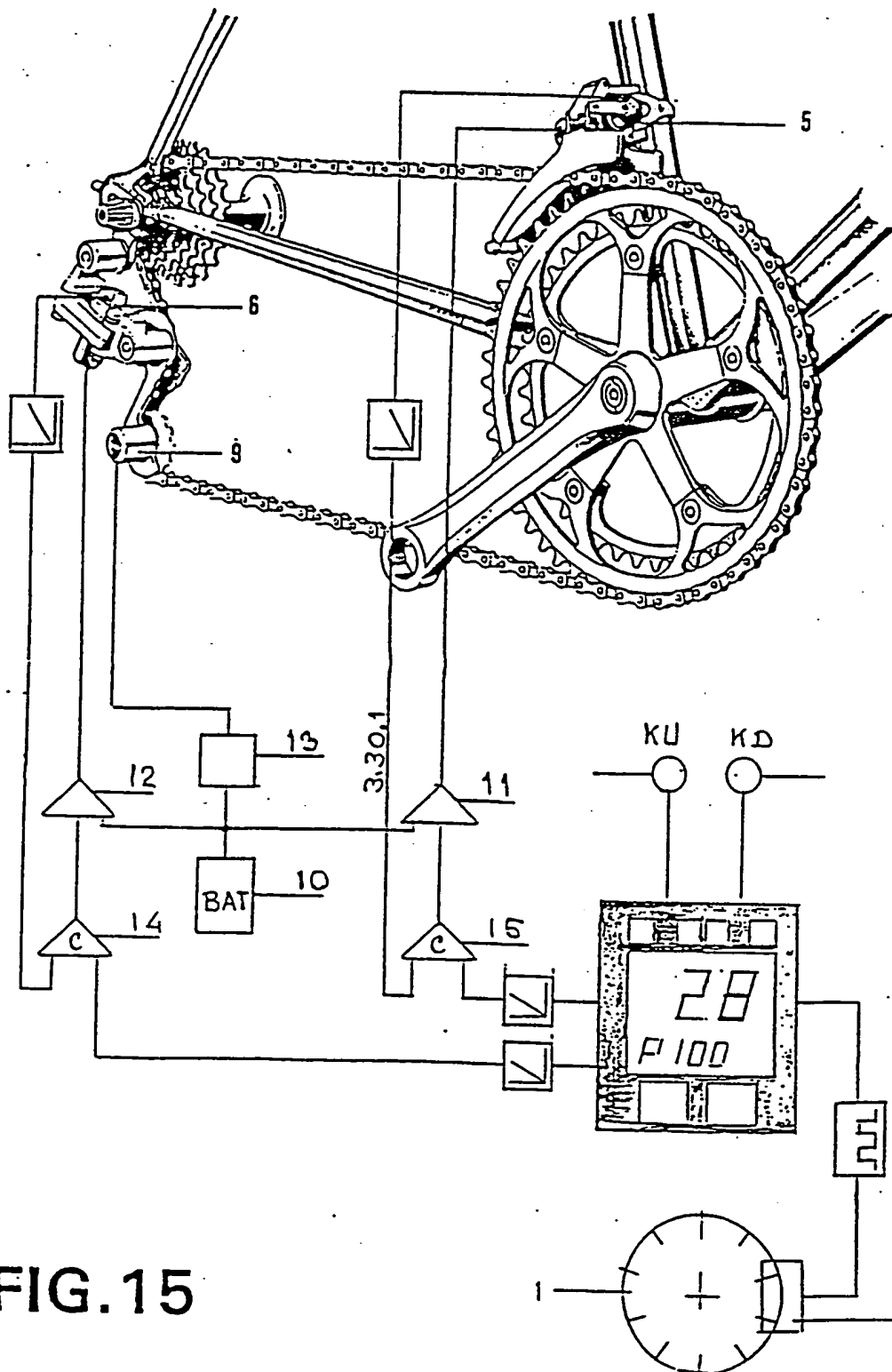


FIG.15

